to the integrity of purpose and dauntless courage which never failed him. Sir Spencer Walpole says justly,

"Of all the men I have ever known, his ideas and his standard were—on the whole—the highest" (ii. 27).

He proceeds—

"He recognised the fact that his religious views imposed on him the duty of living the most upright of lives."

A very unfair use has, I think, been made of this opinion, which I am persuaded is based on a profound misconception. However derived, it is in an innate sense of moral beauty that I prefer to find the true secret of Huxley's life. W. T. THISELTON-DYER.

TERRESTRIAL MAGNETISM AND ATMOSPHERIC ELECTRICITY.

The Norwegian North Polar Expedition, 1893–96. *Scientific Results.* Edited by Fridtjof Nansen. Vol. ii. (London: Longmans, Green and Co., 1901.)

Report on Observations in Terrestrial Magnetism and Atmospheric Electricity made at the Central Meteorological Observatory of Japan for the Year 1897. Pp. 60. (Tokio: Central Meteorological Observatory.)

THE first of the above volumes consists of three memoirs, numbered VI., VII. and VIII., written respectively by Prof. H. Geelmuyden, Mr. Aksel S. Steen and Prof. O. E. Schiøtz. In a brief preface Dr. Nansen states that the great majority of the observations dealt with were made by Captain Sigurd Scott-Hansen.

VI. *Astronomical Observations.*—In a preface, pp. vii. to lx., Prof. Geelmuyden describes the astronomical instruments and the circumstances of their use. His principal object is to determine the drift of the *Fram* and the track of Nansen and Johansen after leaving the ship. The results are embodied in two large scale charts (in a pocket at the end of the volume). A second object is to determine the azimuth in connection with the observations of magnetic declination.

The latitude and local time were found by altitude observations, the sun alone being available during part of the year. For the determination of longitude, and of the chronometer rates, a variety of data were accumulated. There were observations during two eclipses, a few lunar distances and a number of observations of eclipses of Jupiter's satellites. In connection with these last data there is an enumeration of corresponding observations at various observatories, and a discussion of the theory and of various sources of uncertainty. The differences between the chronometers in use from 1893 to 1896 are recorded and discussed. The difficulties met with in reducing the astronomical observations are considerable. Most referred to a station in motion, while many were taken at extremely low temperatures, under conditions when ordinary astronomical formulæ for refraction, &c., are open to question. The differences between the chronometers are not always easy to explain, and the data as to their temperature corrections are somewhat uncertain. As to the data obtained by Nansen and Johansen in their journey, in Prof. Geelmuyden's words,

"the observations during this expedition, where the principal work of the travellers was very often a struggle for life, and where the instruments had to be handled in temperatures down to −40° C., with no other source of heat than the observer's own body, could not attain any high degree of accuracy" (p. lvii.).

The fact that the observations were made at all is the strongest possible evidence that scientific zeal is compatible with the possession of remarkable physical courage and resolution.

After Geelmuyden's preface follow tables, pp. 1–136, giving full details of all the astronomical observations, with a few explanatory notes.

VII. *Terrestrial Magnetism.*—In his introduction, pp. 1–9, Steen describes the instruments. Acknowledgment is made of the assistance rendered by Dr. Neumayer, of Hamburg, who selected the apparatus and had some of it made under his own eye. The great majority of the observations were taken on the ice, inside a tent or a house of snow or ice. "As a defence against bears . . . a weapon was always at hand, generally a revolver." The position of this useful but embarrassing auxiliary and its influence, or absence of influence, on the magnets is a frequent item in the observational records. The different magnetic elements are discussed separately. The declination observations occupy pp. 10–61. The majority were taken with a "Neumayer Declinatorium," of which the principal feature is that its magnet consists of "two laminæ, between which the mirror was fixed"; the magnet rested on a pivot, but could be inverted so as to determine or eliminate the collimation error. Declination results are also deduced from the deflection experiments, intended primarily for the determination of the horizontal force. There were in all about 130 days on which declinations were obtained. The *changes* observed during each of these days are shown graphically, occupying seventeen plates. The observations seldom extended over more than two or three hours on any one day, and in no case was there a continuous day's record. On November 24, 1894, in the course of fifteen minutes, the declination changed fully 26°. On no other occasion did the observed range exceed a quarter of this; but changes of 2° or 3° in the course of an hour or two were not uncommon.

The discussion of the horizontal force observations occupies pp. 62–126, the results being summarised on pp. 119–126. The apparatus was by Zschau. Observations of vibration and deflection were made much in the usual way. The moments of inertia of the two magnets used had been determined, but only approximately, and instead of employing the values so calculated use is made for each magnet of a "constant," involving the moment of inertia, which was determined by observations made at Hamburg and Wilhelmshaven. In some instances the horizontal force is deduced from a deflection experiment alone, by means of a second "constant" involving the magnetic moment of the deflecting magnet. The times of vibration were taken without a telescope, and no observations were made on the torsion of the silk suspension. Mr. Steen also experienced some trouble in connection with the temperature coefficients, which had not been determined at Arctic temperatures.

The inclination observations are discussed on pp. 127–165. The instrument used was a Fox circle, as

modified by Neumayer, with two needles and deflectors. In all there were ninety-two observations of inclination. In treating them, Mr. Steen encountered difficulties. In general, the magnetic axis of a dip needle is inclined to the line of geometrical symmetry, the position of which is read, while the C.G. departs from the axis of rotation. The former source of index error is usually eliminated by reading the needle with its face alternately towards and away from the face of the circle; whilst the latter source of error is removed by reversing the needle's magnetisation in the middle of each experiment. The needles, however, of a Fox circle are never reversed, and the observer in the present case had always used the needles in an invariable position. Assuming constancy in the magnetisation, the error from the first source would remain constant, but that from the second source would vary with the inclination. The resulting error is represented by Mr. Steen through a formula involving three unknown constants, but he finds the data insufficient for determining these directly. Eventually, by having recourse to some results obtained with the deflectors of the Fox apparatus and to corresponding values obtained for the horizontal force, and making certain assumptions, he arrives at numerical results. Some doubt may, however, be felt as to the measure of success attending Mr. Steen's courageous efforts, and this is the more to be regretted because the index correction applied averages about 50′.

The total intensity is dealt with on pp. 166–180. A considerable number of observations had been made with the Fox apparatus; the data, however, for converting these to absolute measure were not, in Mr. Steen's opinion, satisfactory. Accordingly, he contents himself with a list of the observational results,

"partly for possible future utilisation, and partly, too, to show what might have been done with the instrument if the necessary determination of the constants had been forthcoming" (p. 168).

Mr. Steen finishes with two tables, the first, pp. 183–188, summarising the individual results for the magnetic elements, along with the corresponding *theoretical* results, which Dr. Ad. Schmidt had the kindness to calculate from his values of the Gaussian constants for the epoch 1885. The discrepancies, which in the case of both the horizontal force and the inclination seem always of one sign, are often considerable. This may be partly due to the secular change, for which no allowance could be made. The second table arranges the observational results in groups.

VIII. *Pendulum Observations.*—Prof. Schiøtz in his introduction describes the apparatus, which consisted of a von Sterneck's outfit with two half-second pendulums. The periods were observed at Vienna, also at Christiania before and after the expedition, and Schiøtz concludes that practically no change had occurred. During the expedition one observation was made on shore near the Kara Sea, three on the ice, and seven inside the *Fram* when frozen in. Particulars of each experiment are given in full. The geographical coordinates of the stations and the corresponding times of swing are summarised on p. 55. To deduce absolute values for g, Schiøtz utilises the times of swing observed at Vienna and Christiania, together with the absolute values found for gravity at these places by von Oppolzer and himself. The values thus deduced for gravity at the polar stations are compared on p. 60 with the theoretical values given by Helmert's formula for g. Of the ten experiments taken on board ship or on the ice, five give values above and five values below the theoretical. The mean departure from the theoretical values, taken irrespective of sign, amounts only to three parts in 100,000; on the average the observed value exceeds the theoretical by one part per 100,000. Schiøtz believes, however, that the irregular movements due to ice motion must have slightly increased the observed values of g. His conclusion on p. 63 is as follows:

"The observations show that gravity may be regarded as normal over the polar basin; and as it is not probable that this is a peculiarity of the Polar Sea, we are led to the assumption that gravity is normal all over the great oceans. The increased attraction observed on oceanic islands must, therefore, only be due to the local attraction of the heaped up masses . . . that form the islands."

Prof. Schiøtz seems here rather a long way from his base. He devotes pp. 63–86 to drawing "some conclusions respecting the constitution of the earth's crust." A supplement, pp. 87–90, advances arguments which, in Schiøtz's opinion, justify the belief that the influence due to the lack of absolute rigidity in the supports on the pendulums' periods was the same throughout the voyage as at Christiania.

The writers of the three memoirs have clearly acted on the view that the circumstances of Nansen's polar journey were so unique as to justify an unusual amount of detail in recording the observations, and they have spared themselves no trouble in their anxiety to utilise the data to the very utmost. A critic may perhaps, however, be pardoned the doubt whether greater compression of details and greater reserve in theoretical deductions might not have led to a work of fully greater utility. Be this as it may, the volume is to be welcomed as exceedingly opportune in view of the approaching Antarctic expeditions. Those responsible for the exercise of foresight in connection with the apparatus, or the observational programmes of these expeditions, would be well advised in giving its contents their careful consideration.

According to the preface of the second work mentioned at the head of this notice, the Central Meteorological Observatory of Japan, at Tokio, was established in 1890, and "was rebuilt in July, 1897." (?) It possesses two underground magnetic rooms, one for photographically recording, the other for eye-reading, instruments. The former set of instruments are Mascart magnetographs, the latter are said to be of a similar type. The instruments for absolute observations are illustrated in a plate at the end of the volume. The declination and horizontal intensity are observed with an instrument due to Prof. Tanakadate, possessing some unusual features, of which a fuller description is given in the *Proc. R.S.E.* for 1884–6. The times required for taking the several observations are given as: declination, 5 minutes; horizontal force, 20 minutes; inclination, 20 minutes! Absolute observations are taken on only one day a month, but the operations are repeated

several times; there are also monthly determinations of the curve scale values. The necessary temperature corrections are based on direct experiments on one occasion when the magnetograph room was artificially heated. Hourly measurements are made of all the magnetic curves and the results appear in tables, one for each element for each month. In addition to the hourly readings, each table gives the daily mean, maximum, minimum and "range" (maximum less minimum); it gives also the monthly mean for each hour of the day, and the means for the month of the diurnal maxima, minima and "ranges." The general character of each day, whether quiet or more or less disturbed, is also noted. The monthly means are summarised on p. 59, and there are curves of diurnal variation for each month and for the year.

The mean monthly diurnal variations are also analysed in Fourier's series. The fact should be noted that the "mean range" of any element for each month being the mean of the differences between the daily maxima and minima, irrespective of the times of their occurrence, is necessarily larger than the range shown in the mean monthly diurnal variation; it may be largely influenced by the occurrence of magnetic disturbances. For instance, the "mean range" in the horizontal force is given as greater in December than in any other month except April, but the value in December is considerably affected by the occurrence of two or three exceptionally large "ranges." The mean monthly diurnal variations are less exposed to accidental influences; their nature is most easily followed in the curves. The amplitude of the regular diurnal variation in both declination and horizontal force appears least in November. The amplitudes in January appear surprisingly large compared to those in the last three months of the year.

The atmospheric electricity installation consists of a Kelvin water-dropper, the discharge tube of which projects "about 2 metres" at a height of 1·7 metre above the ground. This is connected to the needle of a quadrant electrometer, the quadrants of which are connected the one pair to the positive the other pair to the negative pole of a battery of water cells, the centre of which is to earth. This seems the same arrangement as at Kew. The scale value of the curves is determined weekly. The hourly readings are recorded in tables, one for each month. The daily means, maxima, minima and "ranges" are recorded as in the magnetic tables, also the nature of the daily weather. Hourly means are also given for each month, but in forming these a considerable number of individual results are omitted as being abnormal. Amongst the values omitted are most of the negative potentials, and some entire days are excluded on which negative readings were numerous. The measurements of potential being all given in volts, one can follow readily the annual change, which is more than usually pronounced. Thus the mean potential for the year being 47·2 volts, the mean voltage for the three months December to February was 93·2, while that for the three months July to September was only 9·0; the maximum monthly mean was 112·8 in December, the minimum 6·9 in August. It may be added that the exceptionally low value in August appears in no way due to exceptional occurrences of negative potential.

The mean diurnal variations for the several months are illustrated by curves. As usual there is a marked tendency to a double diurnal variation; but the principal maximum occurs between 6 and 8 a.m., instead of, as is customary, in the late evening. Further, the principal minimum is found, the whole year round, in the early afternoon, usually from 2 to 3 p.m. These results possess a special interest from their apparent irreconcilability with views due to Chauveau which have recently met with considerable recognition.

Another notable feature is the size of the mean diurnal variation. The largest mean hourly value of the potential is in most months some four or five times the smallest; for instance, amongst the mean hourly values in December the maximum was 187·6, the minimum 42·1, while the corresponding values in August were 13·7 and 2·8. The peculiarities shown by the atmospheric electricity results at Tokio are, to a considerable extent, manifested by observations made during a series of years in the Batavia Observatory, but though Batavia is much nearer to the equator than Tokio, the results at the latter station show the greater departure from those ordinarily recorded in Europe.

What has been said will suffice to show the interest of the volume, and the evidence it affords of the progressive spirit in Japanese science. The continuance of the observations, and also of the practice of describing them in English (sometimes with Japanese equivalent), is much to be desired. There are, however, one or two points where some friendly criticism may be offered. The variation in the scale value of the horizontal force curves —from $10^{-6} \times 69$ to $10^{-6} \times 57$ C.G.S. units for 1 mm.—is excessive; and the vertical force scale values show even larger variations (1 mm. $= 10^{-6} \times 82$ in April, $10^{-6} \times 239$ in June, and $10^{-6} \times 79$ in November). Changes such as these, unless produced designedly at known times, introduce uncertainties into at least the annual variation in the amplitudes of the diurnal inequalities. Again, the temperature coefficients are so large for both the horizontal and vertical force magnetographs that appreciable uncertainty must be introduced into the diurnal variations unless the changes of temperature are known with extreme accuracy. Under such conditions, the employment of *six* significant figures in the tables of monthly means of the diurnal variations of the force components seems hardly well advised.

In the case of atmospheric electricity, 1 mm. of curve ordinate answered, on the average, to 3·86 volts in February, 1·15 in August and 2·69 in December. If, as one would rather *infer* from the preface, the number of battery cells in use varied from 30 to 50, one would not be surprised at a considerable change in the scale value, and it would be only good policy to have the scale contracted in winter when the mean potential is large. The changes recorded in the scale value seem, however, too large to be wholly accounted for in this way, and they do not exhibit so regular a fluctuation as to suggest design. A little further information on these points would enable the critic to pronounce with greater assurance on the value of the results.

C. CHREE.